



TUBULAR REACTOR FOR CATALYTIC REACTIONS

The invention relates to a tubular reactor for catalytic reactions according to the concept of patent claim 1.

Usually, such reactors exhibit a reactor jacket containing a heat carrier that circulates around a contact tube bundle, which extends between a tube plate at the reaction gas inlet side and a tube plate at the reaction gas outlet side, as well as gas inlet and gas outlet hoods spanning the face sides of the two tube plates. The process gas, usually a gas mixture, that is to be brought to reaction enters a contact tube that contains a catalytic mass via the gas inlet hood and after passing said contact tube exits the reactor via the gas outlet hood. The gas inlet may be located either on the top or bottom side, and as a whole the heat carrier may pass through the reactor in parallel flow or counter flow with regard to the process gas flow. The reactor can also have a multi-step design as shown, for example, in DE 22 01 528 C, Fig. 5.

Usually, the process gas stream is comprised of two or more material streams that are combined shortly before entering the reactor, that is, its gas inlet hood. In this course, secondary reactions that are harmful to the process or even ignition and deflagration may occur, especially in the immediate surrounding of the generally relatively hot tube plate. Examples of such reaction processes are the production

of maleic acid anhydride, phthalic acid anhydride, acrolein and acrylic acid.

Fillers of ceramic materials or a wire mat mesh have been introduced into the gas inlet hood in an effort to prevent such secondary reactions. Other attempts consisted of insulating the tube endings by using cylinders, because the highest temperatures occur generally at the tube plate on the gas inlet side in the area of the tube ending. However, in the end, none of these measures proved effective or at least dependable for preventing the above mentioned secondary reactions.

For this reason, it is the objective of the invention to design a tubular reactor according to the concept such that secondary reactions, especially ignitions and deflagrations, are dependably prevented inside the gas inlet hood.

This objective is essentially achieved through the characteristic features of claim 1. The subclaims offer additional advantageous design options.

The respective heat insulation layer at the tube plate on the gas inlet side accomplishes on the gas inlet side that the entering process gas is kept from the hot tube plate and on the side of the heat carrier that circulates around the contact tubes and that the tube plate is kept cool in relation

to this heat carrier.

Preferred exemplary embodiments of the respective tubular reactor are described in greater detail below based on the drawings, wherein

Fig. 1 shows a schematic longitudinal section through a tubular reactor subject to the invention in a first embodiment together with connecting elements,

Fig. 2 shows a schematic longitudinal section through an end section at the gas inlet side of such a tubular reactor, however, in a variation,

Fig. 3 shows a schematic longitudinal section through an end section at the gas inlet side of a tubular reactor as in Fig. 1, however, in a different variation,

Fig. 4 shows a schematic longitudinal section through an end section at the gas inlet side of a tubular reactor subject to the invention in a different embodiment,

Fig. 5 shows a schematic longitudinal section through an end section at the gas inlet side of a tubular reactor subject to the invention in another embodiment, and

Fig. 6 shows a schematic longitudinal section through an

end section at the gas inlet side of a tubular reactor subject to the invention in yet another embodiment.

Easily comparable elements that occur in the individual Figures were given the same reference number.

The tubular reactor 2 shown in Fig. 1 features in typical manner a vertical tube bundle 8 that stretches inside a cylindrical reactor jacket 10 from a tube plate 4 at the gas inlet side to a tube plate 6 at the gas outlet side with the two tube plates 4 and 6 being attached to said cylindrical jacket in a sealed manner. The tube plate 4 at the gas inlet side is spanned by a gas inlet hood 12 and the tube plate 6 at the gas outlet side is spanned by a gas outlet hood 14, with both hoods being attached to the respective tube plate in a sealed manner. The individual tubes, e.g., 16, of the tube bundle 8 contain a gas-permeable catalytic mass. The reaction or process gas that is to be brought to a reaction is fed into the gas inlet hood 12 via a gas supply line 18, while the process gas that has passed through the tube bundle 8 and that has gone through the reaction process is removed from the gas outlet hood 14 via a gas removal line 20. Ring channels 22 and 24 surrounding the reactor jacket 10 close to the two tube plates 4 and 6 make possible the supply and removal of a heat carrier, which is in a liquid state at least when the reactor is in operation, into or from the reactor jacket 10, where said heat carrier circulates around the individual tubes,

e.g., 16, of the tube bundle 8 to remove the reaction heat. The flow of the heat carrier can be directed in a desired manner or, if required, distributed across the cross section of the reactor jacket as shown by using two types of guide plates 26 and 28. The heat carrier that is removed from the reactor jacket 10 via the ring channel 22 is returned to the reactor jacket 10 via the ring channel 24 by using a pump 30 whereby a controllable partial flow is guided through a cooling device (not shown here) via branch lines 32 and 34.

The process gas supplied to the reactor via the gas supply line 18 is (in this case) comprised of two partial streams 36 and 38 that are preheated using the heat exchangers 40 and 42, mixed in a mixing device 44 in order to be supplied to the gas inlet hood 12 via the gas supply line 18 as the aforementioned process gas.

In some cases, the supplied process gas is by itself already very reactive, especially if it has had contact with hot surfaces with the tube plate generally being the hottest surface within the space under the gas inlet hood 12. For this reason, the invention provides a heat insulation for the tube plate 4 either against the heat carrier that circulates around the tube bundle 8 as shown in Fig. 1, for example, or against the entering process gas as shown in Fig. 3, or both. In the one case, the insulation's effect is that the tube plate is kept comparatively cool and in the other case that the process

gas is prevented from contact with the hot tube plate.

According to Figures 1, 2 and 3, the heat insulation layer 46 that has been applied to the heat carrier side of the tube plate 4 consists of, for example, ceramics, such as a glass frit, or of a heat-resistant solid material and tightly surrounds the individual tubes, e.g., 16, just as tight as it connects to the reactor jacket 10. While the heat insulation layer 46 according to Fig. 1 has a consistent thickness, its thickness increases towards the center according to Fig. 2 under the assumption that the tube plate usually has the highest temperature in that area.

It is understood that for other temperature distributions, the profile of the heat insulation layer, e.g., 46, may have a different shape. For example, the heat insulation layer 46 can, as shown in Fig. 3, feature a collar 48 at the edge of the tube plate 4 along the interior wall of the reactor jacket 10 in order to keep the temperature gradient at the connection of the reactor jacket to the cooler tube plate, and thus, the temperature stress low. As can be seen from Fig. 3 as well, the thickness of the heat insulation layer 46 can also be different - generally greater - in the tube-free zones of the reactor than in the tube zones in order to accommodate for the normally greater heat of the tube plate in these zones. It is furthermore conceivable to vary the composition of the heat insulation layer instead of the thickness or the thickness of

the heat insulation layer alone, either by varying the amount ratio of its components or by selecting completely different materials. Furthermore, the heat insulation layer, such as 46, for example, can be limited to partial areas of the tube plate, for example, the tube-free zone or the edge area of the tube plate at the transition to the reactor jacket 10.

The same applies to the heat insulation layer 50 that is applied to the tube plate at the gas inlet side according to Fig. 4. It differs from the heat insulation layer 46 according to Figures 1 and 2, however, in that it must contain openings, such as, for example, 52, that correspond to and are in line with the interior cross-section of the individual tubes, such as, for example, 16, in order to provide the process gas unobstructed access to the tubes.

As indicated in Fig. 4, the gas inlet hood 12 may in addition to the insulation of the tube plate at the gas inlet side contain a filler 54 of ceramic materials, a wire mat mesh or similar material. Furthermore, the gas inlet hood 12 may be made of stainless steel or may have a reaction-inhibiting coating on the inside. Finally, by polishing of the interior surface, the accumulation of catalytic dust blown in from the tubes may be made more difficult.

Fig. 5 shows, in this aspect similar to Figures 1 and 2, a tube plate 60 that is insulated at the heat carrier side.

However, in this case the heat insulation layer consists of a chamber 64 that is closed against the reaction zone 67 of the reactor. The chamber 64 exhibits inlets and outlets 66 and 68 one above the other for a cooling medium as well as a guide plate 70 between the inlet and outlet that forces the cooling medium to flow along the tube plate 60 as well as the separator disk 72 that separates the chamber 64 from the reaction zone 62. The pipes, such as 16, for example, penetrate the separator disk 72 in a sealed manner.

The respective cooling medium can be made of the same or a different medium as the heat carrier in the reaction zone 62. In the first case, it may be diverted at a suitable location after the re-cooling from the heat carrier circulation according to Fig. 1. Also, possible smaller leakages at the tube penetrations through the separator disk 72 are not crucial. Still, with regard to the reaction zone 62, about the same pressure should be maintained in the chamber 64 in order to keep leakage streams at the tube penetrations to a minimum.

The chamber 64 can also be evacuated or filled with an immovable solid, liquid or gaseous heat insulation medium, such as sand, oil or air, for example. In this regard, a liquid or gaseous heat insulation medium can be prevented from circulating through an installed cell structure. In any case, the cooling or heat insulation medium used in the chamber 64 should be one that is incapable of reacting with the heat

carrier used in the reaction chamber 62.

Basically, such chambers can be used at the gas inlet side as well as the heat carrier side of the tube plate on the gas inlet side and may, again, only stretch across part of the tube plate, such as the tube-free zone or the edge zone.

According to Fig. 6, a heat insulation layer 80 on the heat carrier side of a tube plate 82 on the gas inlet side simply consists of a stream-calming zone of the heat carrier that is the result of installations 84 in the shape of honeycombs or concentric ring structures, where the heat carrier will assume a lower temperature than in the actual reaction zone due to the tube plate being cooled by the incoming process gas, regardless whether the reactor operates in parallel or counter flow mode. This applies even more when the contact tubes are not filled with catalyst all the way to the tube plate.

The installations 84 can, but do not necessarily have to be covered by a plate 86 as indicated in Fig. 6 by a dashed line and can also be sealed towards the tube plate 82.

Basically, the invention can be applied to exothermally as well as endothermically operating reactors or multi-step reactors, such as the one shown in Fig. 5 of DE 22 01 528 C regardless whether the gas inlet is on the top or bottom side and the heat carrier passes through the reactor in parallel

flow or counter flow mode.

It generally applies that the tube ends at the tube plate on the gas inlet side can be entirely or in part kept free of catalytic mass or can be filled with an inert material or a mixture of such a catalytic material in order to limit the reaction temperature close to the tube plate.